REMARKS

Statement under 37 C.F.R. §1.116

Applicants submit the following comments in response to the characterization of the cited references made in the most-recent Office Action. These remarks are only now necessary and timely, as the issues have been more narrowly refined by the interpretations of the references in the most-recent Office Action. Accordingly, Applicants respectfully request that the following comments be considered at this time.

35 U.S.C. §103

Claims 1-15, 17-34 and 36 were rejected under 35 U.S.C. §103(a) as being unpatentable over US 6,184,176 B1 (Khare) in view of various combinations of US 4,464,252 (Eberly); WO 02/22763 A1; US 4,911,823 (Chen *et al.*); and US 4,179,361 (Michlmayer).

By way of background, four techniques for removing sulfur from hydrocarbon fuels are described, as follows, in the Applicants' specification:

> Techniques for the removal of sulfur from hydrocarbon fuels can be divided into the following four general categories: 1) hydrodesulfurization, which can be characterized by the conversion of organically bound sulfur to H_2S in the presence of hydrogen; 2) cracking, which can be characterized by the conversion of organically bound sulfur to H_2S; 3) chemical absorption, which can be characterized by the abstraction of sulfur from the fuel at moderate temperature; and 4) physical absorption, which can be characterized by the removal of sulfur-containing compounds from the fuel at low temperature.[1]

The pending claims include two independent claims (*i.e.*, claims 1 and 28). Both of these claims fall with the third technique, chemical absorption (*i.e.*, #3 in the list, above). None of the cited references target this technique with the metal oxides cited by the Applicants.

In particular, claim 1 specifies that the primary desulfurization agent is a metal oxide selected from molybdenum oxide, tantalum oxide, tungsten oxide and combinations thereof and that the sulfur is removed from the hydrocarbon fuel at a (moderate) temperature in the range of 350 to 600°C, where sulfur replaces the oxygen in the metal oxide to form metal sulfide and also

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[1] USSN 10/617,912, page 2, lines 1-7.

that the metal sulfide is converted back to the metal oxide at a temperature in the range of 350 to 600°C, where oxygen replaces the sulfur.

This chemical-absorption technique is exemplified by the following typical reactions, set forth in the specification,[2] with "M" representing the transitional metal species:

$$MO_x + x\ CH_3SCH_3 \rightarrow MS_x + C_{2x}H_{4x} + x\ H_2O \quad (3)$$

$$MO_x + x\ H_2S \rightarrow MS_x + x\ H_2O \quad (4)$$

Meanwhile, the following example reaction for regeneration is characterized in the specification[3] as follows:

$$MS_x + 3x/2\ O_2 \rightarrow MO_x + x\ SO_2 \quad (6)$$

The three absorbents identified for use in this chemical-absorption technique in claim 1 exhibited superior performance for removing sulfur via chemical bonding, as evidenced by the following table, presented as "Table 2" in the specification[4]:

Absorbent	Sulfur Removal (%)
19 wt% MoO_3/Al_2O_3	65
29 wt% Ta_2O_5/Al_2O_3	35
22 wt% WO_3/Al_2O_3	31
16 wt% $ZnTiO_3/Al_2O_3$	28
21 wt% ZnO/Al_2O_3	11
11 wt% MnO_2/Al_2O_3	8

None of the cited references suggest that oxides of molybdenum, tantalum, and tungsten in a chemical absorption process can produce superior results, such as those evidenced in the above table. The shortcomings of each of the cited references will now be further discussed, in turn.

Fist, as noted by the Examiner,[5] Khare discloses a sorbent composition that includes zinc oxide, which was found to produce considerably inferior results when used in the chemical

[2] *Id.*, page 9, lines 4-7.
[3] *Id.*, page 9, lines 9-10.
[4] *Id.*, page 13, lines 13-19.
[5] Office Action of July 14, 2006, page 3.

absorption experiment reported in Table 2, above (*i.e.*, the zinc oxide sample removed only 11% of the sulfur, compared with 31%, 35% and 65% for the claimed compounds in the experiment). Moreover, the zinc oxide does not appear to react with sulfur to form zinc sulfide in the process of Khare. Rather, sulfur is removed in the process of Khare by "substantially zero valence cobalt."[6] Consequently, the sulfur removal process of Khare is not one in which the sulfur from the hydrocarbon fuel is substituted for the oxygen in a metal oxide as specified in Applicants' amended claims, but rather is one in which a reduced metal bonds to the sulfur.

Second, the Examiner asserted that "Eberly discloses using molybdenum and tungsten oxides to 'Catalytically remove sulfur from petroleum fractions, crude oils, and other mixtures of hydrocarbons' (Col. 1, lines 12-20)."[7] The applicant respectfully disagrees that this disclosure of Eberly's refers to a chemical absorption process. Rather, Eberly is referring to the common usage of molybdenum and tungsten sulfides as hydrodesulfurization catalysts according to the first technique described in the Applicant's specification.[8]

Third, the Examiner asserted that Eberly discloses a process for removing sulfur from a hydrocarbon using a sorbent containing MoO_3 on alumina and that the sorbent is used in a process at a temperature with the claimed range.[9] Applicant respectfully disagrees as to the allegation of temperature. The temperature range suggested by Eberly is 100°F to 600°F (*i.e.*, 38°C to 316°C). This range appears to represent the low-temperature range for physical adsorption, cited in the quoted text on page 2 of this Response as technique #4, and is below the lower limit of 350°C set forth in claim 1. Moreover, Eberly states that "it is quite possible that the molybdenum is also capable of combining, and hence may in fact combine with the sulfur compound."[10] This description is representative of the physical-adsorption technique (#4), in which the entire sulfur-containing hydrocarbon compound is removed from the fuel stream, rather than the chemical-absorption technique (#3), in which the sulfur atom alone is extracted from the fuel. Moreover, previously cited U.S. Patent 5,157,201 (Norris) teaches that sulfur removal via physical adsorption actually decreases with increasing temperature (above about

[6] U.S. 6,184,176 B1 (Khare), Col. 5, line 59, through Col. 6, line 21.
[7] Office Action of July 14, 2006, page 9.
[8] U.S. 4,464,252 (Eberly), Col. 2, lines 5-10.
[9] Office Action of July 14, 2006, page 5.
[10] U.S. 4,464,252 (Eberly), Col. 4, lines 4-6.

100°C).[11] Consequently, Eberly offers no motivation for using molybdenum oxide (or tantalum oxide or tungsten oxide) in a higher-temperature chemical absorption process; and the prior art actually teaches away from using the higher temperatures specified in Applicants claim 1 in the context of a physical-adsorption process.

Fourth, as noted by the Examiner,[12] WO 02/22763 discloses the use of metal oxides (preferably zinc oxide or iron oxide[13]) to remove sulfur. However, WO 02/22763 teaches away from using molybdenum and tungsten oxides.[14] Further WO 02/22763 refers to being "substantially free" of these compounds so as to prevent "substantial conversion of the organic sulfur components into H_2S by reaction with hydrogen gas."[15] Accordingly, WO 02/22763 clearly refers to a hydrodesulfurization process (technique #1 in the recited list on page 2) with the recited metal oxides, from which it is teaching away, rather than to a chemical absorption process, as characterized in claim 1. Consequently, WO 02/22763 does not remedy the deficiencies of Khare.

Finally, Chen and Michlmayer likewise fail to offer any disclosure or suggestion of using any of the recited metal oxides in a chemical-absorption process to remove sulfur.

Claim 28 likewise is directed to a process wherein molybdenum oxide, tantalum oxide or tungsten oxide is used to remove sulfur via chemical absorption and is, therefore, distinguishable from the cited references for many of the same reasons, as noted, above.

Accordingly, Applicants respectfully submit that the cited references, separately and in combination, fail to disclose or suggest the use of molybdenum oxide, tantalum oxide or tungsten oxide is used to remove sulfur via chemical absorption as is specified in both of the independent and respectfully requests that this ground for rejection be reconsidered and withdrawn.

CONCLUSION

On the basis of the foregoing amendments, Applicants respectfully submit that the pending claims are in condition for allowance. If there are any questions regarding these

[11] U.S. 5,157,201 (Norris), Col. 6, lines 3-8 and FIG. 2.
[12] Office Action of July 14, 2006, pages 5-6.
[13] WO 02/22763, in the paragraph bridging pages 6 and 7.
[14] *Id.*, in the two full paragraphs on page 20.
[15] *Id.*, in the second full paragraph on page 20.

amendments and remarks, the Examiner is encouraged to contact the undersigned at the telephone number provided below.

Respectfully submitted,

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